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The invention concerns a Fourierspektrometer with a amplitude-dividing interferometer, which the following components exhibit

- a polarizer mechanism for linear polarizing in interferometers of occurring parallel ray of light from a source of light;
- a doublebreaking drag element for splitting the linear polarized ray of light up into a tidy and an extraordinary jet with in each case the same direction of propagation as that of the linear polarized ray of light;
- a wedge arrangement consisting of doublebreaking material, of two against each other mobile wedges, whereby the two wedges are so arranged that their hypotenuse surfaces border directly together, their long side surfaces are flat and perpendicularly to the direction of propagation of the light in the interferometer, whereby at least one of the wedges is parallel to its hypotenuse surface in such a manner adjustable that the mutual distance of the flat-parallel side surfaces can be varied, and whereby the Zes-axis are turned oriented at least a wedge opposite the Zes-axis of the drag element around 90 DEG; and
- an analyzer mechanism also around a given angle alpha in relation to the polarizer mechanism around the direction the wedge arrangement of leaving ray of light of turned polarization plane.

Such Fourierspektrometer is offered to AG in Switzerland under the designation FT-NIR 4010 by the company Tecan. The heart of a Fourierspektrometers is a amplitude-dividing interferometer, classical-proves an Michelson interferometer, with which a parallel ray of light from a source of light hits under 45 DEG a semidurchlässigen beam splitter, which lets the jet through partly straightforward and partial rectangular reflected. Both partial jets are back-reflected in each case by one perpendicularly in its path of rays plane mirror present on the beam splitter. One of the two mirrors is stationary, while the other one can be shifted on the Z-axis of the partial jet concerned, so that the optical distance, which puts the light back of this partial jet between the beam splitter and the mirror, can be varied. Again the partial jets gathering in the beam splitter interfere with one another and result in a ray of light amplitude-modulated as a function of the position of the mobile mirror, which leaves interferometers perpendicularly to the direction of the ray of light running in from the source of light and either directly to a detector is supplied, or before still another sample brought into the path of rays goes through. From the detector signal with the help of a computer the Fouriertransformierte of the Interferogramms is formed, the one complete optical spectrum of source, instrument (interferometer) and if necessary. Sample represents.

A large disadvantage of the Michelson interferometer is the necessary guide precision of the moved interferometer mirror. With an interferometer of the company Analect in Irvine/California, which is offered under the designation ? Transept?, a importantly larger guidance inaccuracy can be taken in purchase, as as beam splitter an arrangement is used of a mobile and a firm wedge from transparent material. The optical distance, which the partial jet in the ?mobile? arm of the double-armed interferometer puts back, is varied by shifting the wedge. Because the light is led by subject with high refractive index is produced, optical distance differences in the two arms of the interferometer.

The double-armed interferometer arrangement has however still the disadvantage that different thermal changes, z. B. Expansions of the optical elements on the two arms to a serious Dejustierung of the interferometer during the measurement to lead can. This disadvantage does not arise during the initially mentioned, from the company Tecan AG offered arrangement after the generic term, since this arrangement does not exhibit a second arm, which must be compensated opposite a first arm, but the two partial jets in the same place pass the optical elements of the interferometer, and therefore a difference between two spatially separated partial jets cannot at all occur.

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The change of the optical Gangunterschiede during this arrangement are however still limited due to the maximally possible differences in the refractive indices of the materials of the two wedges quite, which limits also the resolving power of the spectrometer. In addition high requirement against the plan parallelism of the opposite long side surfaces of the two wedges, and also Winkelfehler, as well as deviations of the jet direction of the direction must be placed perpendicularly to these side surfaces, z with this structure. B. by a finite divergence of the jet or due to a somewhat inclined adjustment of the jet axle, lead to substantial disturbances in the interference sample. Likewise errors affect themselves negatively with the movement of the mobile wedge along the hypotenuse surfaces.

Task of the available invention is it therefore, a Fourierspektrometer of the kind initially specified going by to be improved that the requirements can be substantially reduced to the angle accuracy of the optical components, in particular the wedge arrangement, without loss at resolving power or measuring accuracy that dynamic errors affect themselves less with the movement of the mobile wedge disturbing and that the optical Gangunterschied of the two partial jets in the interferometer and thus the resolving power of the Fourierspektrometers are increased.

This task is solved according to invention by the fact that stepping into direction of propagation for the first time by the wedge arrangement of the ray of light seen after the wedge arrangement a retroreflector is intended.

Because the ray of light is back-thrown by the retroreflector, it goes through the wedge arrangement at least twice, which entails a double optical distance difference and thus a doubled optical resolving power of the

Fourierspektrometers. Small angle deviations of the path of rays in the wedge compensate themselves automatically, since they are waived with the return of the retroreflektierten jet by the wedge in reverse direction to arise and therefore in the result. For the same reason also dynamic errors compensate themselves with the movement of the mobile wedge. Altogether the requirements can to the angle accuracy of the optical components over approx. during the arrangement according to invention. a power of ten to be reduced. A further advantage consists of the fact that the spectrometer is only half as large in its linear dimension as the structure after the well-known state of the art.

From the block letters ?journal OF Scientific of Instrument?, volume. 37, August 1960, pages 278 to 281 likewise an arrangement is well-known, with which a jet led by a wedge arrangement is back-reflected in itself and led again by the wedge arrangement. With this equipment it concerns however not around a spectrometer, but only a modification of a Babinet compensator, with which by shift of the wedges only optical Gangunterschiede are produced by monochromatic light in the order of magnitude or two wavelengths, whereby the sample between polarizer and analyzer is, while with a spectrometer Gangunterschiede must be produced by several thousand wavelengths. Into the path of rays of such a compensator optical construction units are brought for the investigation of their doublebreaking behavior as well as for optical control of the construction units for inaccuracies. A spectrographic analysis with such an arrangement is not possible.

With a preferential execution form of the Fourierspektrometers according to invention the angle alpha, around which the analyzer mechanism inversely to the polarizer mechanism rotate is, amounts to 90 DEG. The adjustment of the arrangement takes place then to a minimum of the depressing light, which permits the largest adjustment accuracy.

With another execution form the wedge arrangement consists of a being certain and a mobile wedge. Adjusting is substantially facilitated by the being certain wedge in relation to the arrangement with two mobile wedges.

With an execution form of the Fourierspektrometers according to invention the drag element is in the wedge arrangement, in particular in the being certain wedge integrated, whereby the number of components in the interferometer and thus the number of possibilities of error reduced and the spectrometer becomes altogether more compact.

With a further execution form the polarizer and the analyzer are formed by a polarizing beam splitter, whereby the retroreflector is in such a manner arranged that the wedge arrangement runs for the first time for the last time leaving ray of light the coaxially and against-arranged to ray of light occurring the wedge arrangement, the back of the polarizing beam splitter hits and the sample detector arrangement of the Fourierspektrometers is finally supplied. With this execution form the number of linear-polarizing optical instruments of two to one is reduced, so that the possibilities of error continue to decrease still with the individual components and the structure altogether becomes still more compact.

During a preferential further training of this execution form the retroreflector is in such a manner arranged the fact that the retroreflector leaving ray of light is parallel-transferred in relation to ray of light the occurring the retroreflector for the first time for the first time and that in direction of propagation the retroreflector leaving ray of light seen after the wedge arrangement a mirror is arranged for the first time, reflects the ray of light in itself. By it one reaches that the ray of light passes the wedge arrangement altogether four times, what in relation to the arrangement after the generic term of the requirement 1 to a quadruple higher Gangunterschied and thus a four times higher resolving power leads.

The retroreflector can be with execution forms of the invention a cube corner (more corner cube) in addition, it can of a cat eye arrangement consist, which contains either a plane mirror and a hollow mirror or but a plane mirror and a collecting lens. It is substantial that the jet with point symmetry is back-thrown.

With a preferential execution form a light fiber arrangement is intended, which supplies the ray of light of a sample arranged withdrawing from the interferometer outside of the Fourierspektrometers and again the ray of light of the detector mechanism of the Fourierspektrometers withdrawing from the sample. Thus the sample can be spatially far outside of the Fourierspektrometers arranged, so that with the sample change no directly mechanical contact with the spectrometer comes, which the danger of an unintentional Dejustage of the spectrometer further minimized and which opens possibility of making a spectrographic analysis also at places at which a Fourierspektrometer from spatial or other reasons not aufgebau become can.

The Fourierspektrometer according to invention can be operated in all optical wavelength coverages, in which the used materials are doublebreaking transparency and, in particular however with a source of light, which emits wide-band light in the close infrared. Thus vibration and Rotationsspektren can be particularly taken up by liquid molecules.

The invention is more near described and described in the following on the basis the remark examples represented in the design. To the design and the description characteristics which can be inferred can apply with other execution forms of the invention for itself or to several in arbitrary combination individual. Show:

Fig. 1 pattern of a spectrometer after the generic term of the requirement 1;

Fig. 2 pattern of a spectrometer according to invention;

Fig. 3 pattern of a spectrometer according to invention also in the wedge arrangement integrated drag element;

Fig. 4 pattern of a spectrometer according to invention also in the wedge arrangement integrated drag element and polarizing beam splitter;

Fig. 5 pattern of a spectrometer according to invention also in the wedge arrangement integrated drag element, polarizing beam splitter and a mirror retroreflector arrangement, which make a four times going through possible of the ray of light by the wedge arrangement;

Fig. 6a pattern of a cat eye arrangement with plane mirror and hollow mirror;

Fig. 6b pattern of a cat eye arrangement with plane mirror and collecting lens and

Fig. 7 pattern of an arrangement to the lighting lead into those and from the sample.

The Fourierspektrometer in Fig. 1 belonged to the state of the art and is mentioned, like initially, offered by Swiss company Tecan AG. Light from a usually wide-band source of light 1 is formed here in one as lens represented first gunsight arrangement 2 to a parallel ray of light, which goes through an interferometer. Interferometer consists of a polarizer mechanism 3, a drag element 4, a wedge arrangement 5 of doublebreaking material, consisting of a being certain wedge 6 and a mobile wedge 7, whereby the two wedges are so arranged that their hypotenuse surfaces 8 min, 8 min min border directly together, their long side surfaces 9 min, 9 min min are flat and perpendicularly to the direction of propagation of the light in the interferometer, whereby the mobile wedge is parallel to its hypotenuse surface 8 min min in such a manner adjustable that the mutual distance the flat-parallel side surfaces 9 min, 9 min min to be varied can, as well as from an analyzer mechanism 10. From the first gunsight arrangement the 2 into interferometer occurring ray of light is linear polarized in the polarizer mechanism 3. If the Winkellage of the passage direction of the polarizer mechanism 3 in one level is defined perpendicularly to the axle of the parallel ray of light to 45 DEG, then the following drag element 4, which usually consists of a doublebreaking flat-parallel plate, oriented with its Zes-axis concerning the polarizer mechanism 3 is in such a way that perpendicularly parallel ray of light the passing through the drag element 4 is split up into a tidy and an extraordinary jet with in each case the same direction of propagation, D. h. in two portions, the Winkellage 0 DEG linear-polarized their oscillation levels and/or. 90 DEG in the level perpendicularly to the jet axle take. Since the two jet components in the drag element possess 4 different speeds of light, the parallel ray of light does not leave the drag element 4 necessarily linear polarized, but usually elliptically or possibly also circular letter polarizes. The ray of light occurs the wedge arrangement 5, whereby it the flat-parallel, long side surfaces 9 min, 9 min min of the being certain wedge 6 and/or. the larger mobile wedge perpendicularly intersperses 7. The Zes-axis of the wedge arrangement 5 are turned oriented opposite the Zes-axis of the drag element 4 around 90 DEG around the axle of the ray of light. By shifting the mobile wedge 7 along its hypotenuse surface 8 min min therefore the optical thickness of the wedge arrangement 5 can be varied such the fact that them become equal the optical thickness of the drag element 4 and therefore again perpendicularly to each other waives the effect of the fragmentation first of the linear polarized jet in two polarized components with different running times. In this special position the wedge arrangement leaves 5 a parallel ray of light polarized linear under 45 DEG, which occurs now an analyzer mechanism 10, whose passage direction takes the angle position -45 DEG concerning one level perpendicularly to the axle of the ray of light, so that in this case the ray of light in the analyzer mechanism 10 is extinguished. By shifting the mobile wedge 7 however the optical thickness of the wedge arrangement 5 can be changed relative to the optical thickness of the drag element 4 at will, so that the wedge arrangement 5 leaving parallel ray of light will not linear be polarized usually in a Winnkelstellung by 45 DEG, and therefore at least a part of the ray of light the analyzer mechanism 10 abandoned and a second gunsight arrangement 11 to occur can, where the ray of light on a sample 12 and afterwards by a lens 13 on a detector 14 is focused. There the light signals of the Interferogrammes are taken up and passed on to a computer for fourier transformation.

The well-known interferometer arrangement described above is mechanically more compact and also disturbance than classical Michelson interferometers, however high precision demands must be placed against the plan parallelism of the long side surfaces 9 min, 9 min min of the wedge arrangement 5. In addition the maximally possible Gangunterschied between the partial jets is limited by the difference of the refractive indices of the wedge materials. These two disadvantages can be avoided with the Fourierspektrometer according to invention, with which in direction of propagation for the first time of the ray of light seen after the wedge arrangement a retroreflector 15, stepping by the wedge arrangement 5, like z. B. in Fig. 2 shown, intended is. As a result of at least twice passing through of the ray of light the delay plate 4 and the wedge arrangement 5 the double optical distance difference arises as in the case of the linear arrangement after the generic term of the requirement 1, and thus the double resolving power of the interferometer. Small angle deviations of the ray of light with the passage by the drag element 4 and the wedge arrangement 5 compensate themselves, since they are waived when second going through the appropriate optical element in reverse direction to arise in each case and therefore in the result. The same applies to Winkelfehler, which arise due to deviations in the linearity of the movement of the mobile wedge 7 along the hypotenuse surfaces 8 min, 8 min min. A further advantage of the arrangement according to invention consists of the fact that it is only half so long in relation to the linear arrangement.

The wedge 6 must be not necessarily being certain arranged, but can also opposite the wedge 7 be mobile intended. The preferential relative angle position alpha of the analyzer mechanism 10 concerning the polarizer mechanism 3 amounts to 90 DEG, since an optical adjustment is to be managed to a minimum light at the simplest and more details, of the passing through the arrangement. In addition, the relative relative alpha can amount to 0 DEG, so that the let through quantity of light becomes maximum, or also any, intermediate value firmly given in advance to accept, if thereby the luminous efficiency in the detector 14 is to be increased.

Is still more compact in Fig. 3 execution form shown, with which the drag element 4 in the wedge arrangement 5, in particular in the being certain wedge 6 is integrated. The orientation of the Zes-axis of the being certain wedge 6 must be rotated during this arrangement around 90 DEG around the axle of the ray of light in relation to the orientation of the Zes-axis of the mobile wedge 7.

A further saving at optical components and at space requirement of the spectrometer makes the execution form possible after Fig. 4, where the polarizer mechanism 3 and the analyzer mechanism 10 by a only one polarizing beam splitter 16 is replaced. The retroreflector 15 is with this execution form arranged that the ray of light finally leaving the wedge arrangement 5 runs the coaxially and against-arranged to ray of light occurring the wedge arrangement 5, thus in itself is in such a manner reflected. Thus also the lateral dimensions of the structure of interferometer can be shortened.

Fig. a particularly preferred execution form of the invention, with which the ray of light occurs 5 with integrated drag element 4 the retroreflector 15 first by the wedge arrangement, from there shows 5 by the wedge arrangement 5 to a mirror 17 thrown, the jet in itself is reflected and by the wedge arrangement 5 on the retroreflector 15 back-thrown, which throws it parallel-transferred again by the wedge arrangement 5 to the polarizing beam splitter 16. In this way the wedge arrangement 5 with the integrated drag element 4 is gone through altogether four times by the ray of light, which in relation to the linear arrangement after Fig. 1 a quadruple increased optical Gangunterschied and thus a quadruple higher resolving power of the interferometer results in.

The retroreflector 15 can be with execution forms of the invention a cube corner (more corner cube). In addition, it can consist of a cat eye arrangement, those, as in Fig. 6a shown, a hollow mirror 19 contains, which throws the ray of light on a plane mirror 18, which reflects the jet for his part on the hollow mirror 19, where it is back-thrown antiparallelly to its origin direction, or those, as in Fig. 6b shown, of a collecting lens 20 and of a plane mirror 18 to consist can.

The sample 12 can as in Fig. 1 shown, linear between the second gunsight arrangement 11 and a lens 13 arranged its, which focus the light from the sample into a detector 14. Another possibility of the sample detector arrangement is in Fig. 7 shown, where the light from the interferometer, withdrawing from the second gunsight arrangement 11, is steered with the help of a light fiber arrangement 21 into the sample 12 and focused from there again with the light fiber arrangement 21 over a lens 13 into the detector 14. This arrangement has the advantage that the sample can be arranged spatially far outside of the Fourierspektrometers.